Hydrocarbons

Aliphatic (Fatty)

Open chain [Acyclic]

Saturated

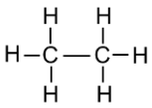
Alkane

All bonds between carbon are single

General formula

C_nH_{2n+2}

EX.



C_2H_6

ethane

unsaturated

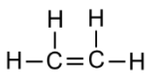
Alkene

Contains one double bond or more between carbon atoms

General formula

C_nH_{2n}

EX.



C_2H_4

ethene

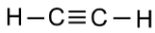
Alkyne

Contains one triple bond or more between carbon atoms

General formula

C_nH_{2n-2}

EX.



C_2H_2

ethyne

Cyclic chain

saturated

(Cyclo Alkane)

All bonds between carbon are single

General formula

C_nH_{2n}

EX.

Cyclo propane

C_3H_6

Cyclo butane

C_4H_8

Cyclo pentane

C_5H_{10}

Cyclo hexane

C_6H_{12}

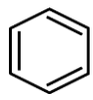
Aromatic (عطريه)

Cyclic only

unsaturated

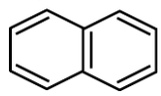
EX.

benzene



C_6H_6

Naphthalene



$C_{10}H_8$

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Alkanes

1 Dry distillation

$$C_3H_7COONa + NaOH \xrightarrow[\Delta]{CaO} C_3H_8 + Na_2CO_3$$

(salt 4C) (alkane 3C)

2 Halogenation (Cl_2 / U.V) by substitution

$$C_2H_6 + Cl_2 \xrightarrow{U.V} C_2H_5Cl + HCl$$

ethane — chloro ethane (ethyl chloride)

3 Thermal catalytic cracking

Long chain alkane ----> Alkane + Alkene + may another alkene

$$C_8H_{18} \xrightarrow{\text{high pressure , heat / Catalyst}} C_4H_{10} + C_4H_8$$

butane — butene

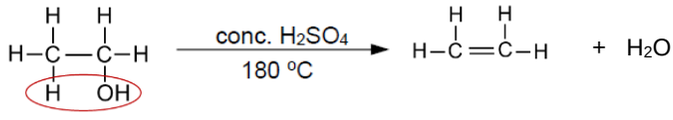
4 Obtaining divided (black) carbon & water gas

$$CH_4 \xrightarrow[\text{no air}]{1000\ ^oC} C + 2H_2$$

$$CH_4 + H_2O \xrightarrow[\text{cat.}]{725\ ^oC} CO + 3H_2 \text{ (water gas)}$$

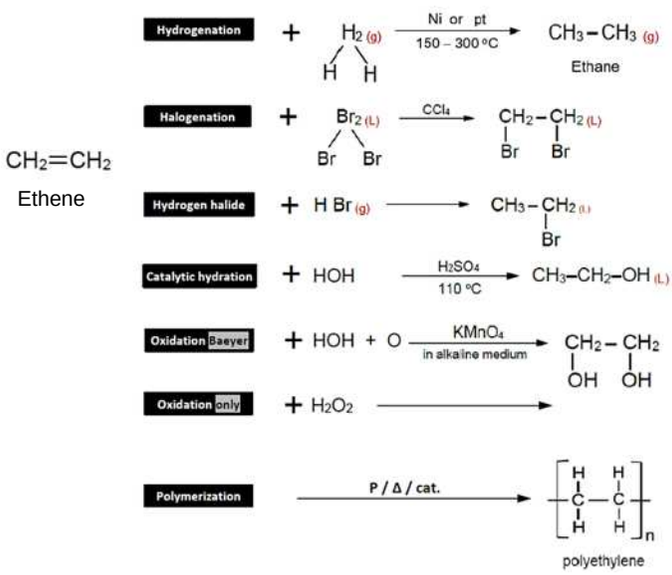
Alkenes

1 preparation of ethene (dehydration of alc. by conc. H_2SO_4 at 180 °C)

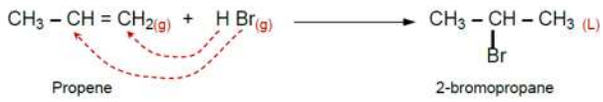


ethanol (ethyl alcohol) — ethene

2 Addition reactions



- **Markownikoff's rule :** " El H troo7 le Rich "



Steps of reaction :

Preparing Ethene C_2H_4

1) Add sulphuric acid to ethanol :

$$C_2H_5OH + H\text{–}OSO_3H \xrightarrow[80\ ^oC]{conc.} C_2H_5OSO_3H + H_2O$$

2) Ethyl hydrogen sulphate decomposed by Δ :

$$C_2H_5OSO_3H \xrightarrow{180\ ^oC} H\text{–}OSO_3H + C_2H_4$$

$$C_2H_5OH \xrightarrow[180\ ^oC]{conc.\ H_2SO_4} C_2H_4 + H_2O$$

Catalytic hydration for Ethene

1) Add sulphuric acid to ethene :

$$C_2H_4 + H\text{–}OSO_3H \xrightarrow{80\ ^oC} C_2H_5OSO_3H$$

2) Hydrolysis for Ethyl hydrogen sulphate :

$$C_2H_5OSO_3H + H_2O \xrightarrow{110\ ^oC} C_2H_5OH + H_2SO_4$$

$$C_2H_4 + H_2O \xrightarrow[110\ ^oC]{H_2SO_4} C_2H_5OH$$

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Alkynes

1 preparation of ethyne (acetylene) (C_2H_2)

- **in Lab.** (dropping H_2O on calcium carbide CaC_2)

$$CaC_{2\,(s)} + 2H_2O_{(L)} \xrightarrow{\text{drops}} C_2H_{2(g)} + Ca(OH)_{2\,(aq)}$$

- **in industry.** (Strong heating then rapid quenching [fast cooling])

$$\underset{\text{methane}}{2CH_4} \xrightarrow[\text{Rapid quenching}]{1500\ ^oC} C_2H_2 + 3H_2$$

2 Addition reactions (2 steps)

Hydrogenation

$$+ \ H_{2\,(g)} \xrightarrow{Ni/\Delta} \xrightarrow[Ni/\Delta]{+ H_2}$$

Halogenation

$$CH{\equiv}CH + Br_{2\,(L)} \xrightarrow{CCl_4} \xrightarrow[CCl_4]{+ Br_2}$$

Hydrogen halide

$$+ \ H\,Br_{\,(g)} \longrightarrow \xrightarrow{+ HBr}$$

Catalytic hydration

$$+ \ HOH \xrightarrow[HgSO_4\ /\ 60\ ^oC]{H_2SO_4\ (40\ \%)} \left[CH_2{=}\underset{|}{\overset{OH}{C}}H \right] \xrightarrow{\text{Rearrange}} CH_3CHO$$

Polymerization — **Trimerization**

$$\xrightarrow{\text{Red hot Ni tube}} C_6H_6$$

Aromatic benzene

- **What will happen to red colour of bromine in ….. ?**

Adding of ….	$C-C$ 1 mole Ethane	$C=C$ 1 mole Ethene	$C\equiv C$ 1 mole Ethyne	1 mole Benzene
2 moles of Br_2 diss. in CCl_4	no change	red color dec. or (no change)	red color removed	no change
1 moles of Br_2 diss. in CCl_4	no change	red color removed	red color removed	no change

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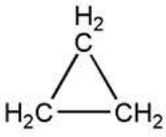
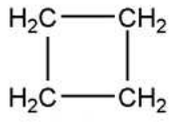
Cyclo-Alkanes

Angle :	60 °	90 °	near 109.5 °	near 109.5 °	near 109.5 °

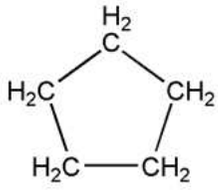
increase angel , increase stability , decrease activity



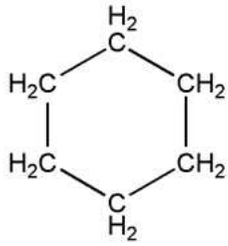
cyclopropane C_3H_6



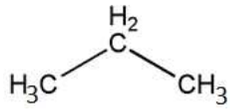
cyclobutane C_4H_8



cyclopentane C_5H_{10}



cyclohexane C_6H_{12}

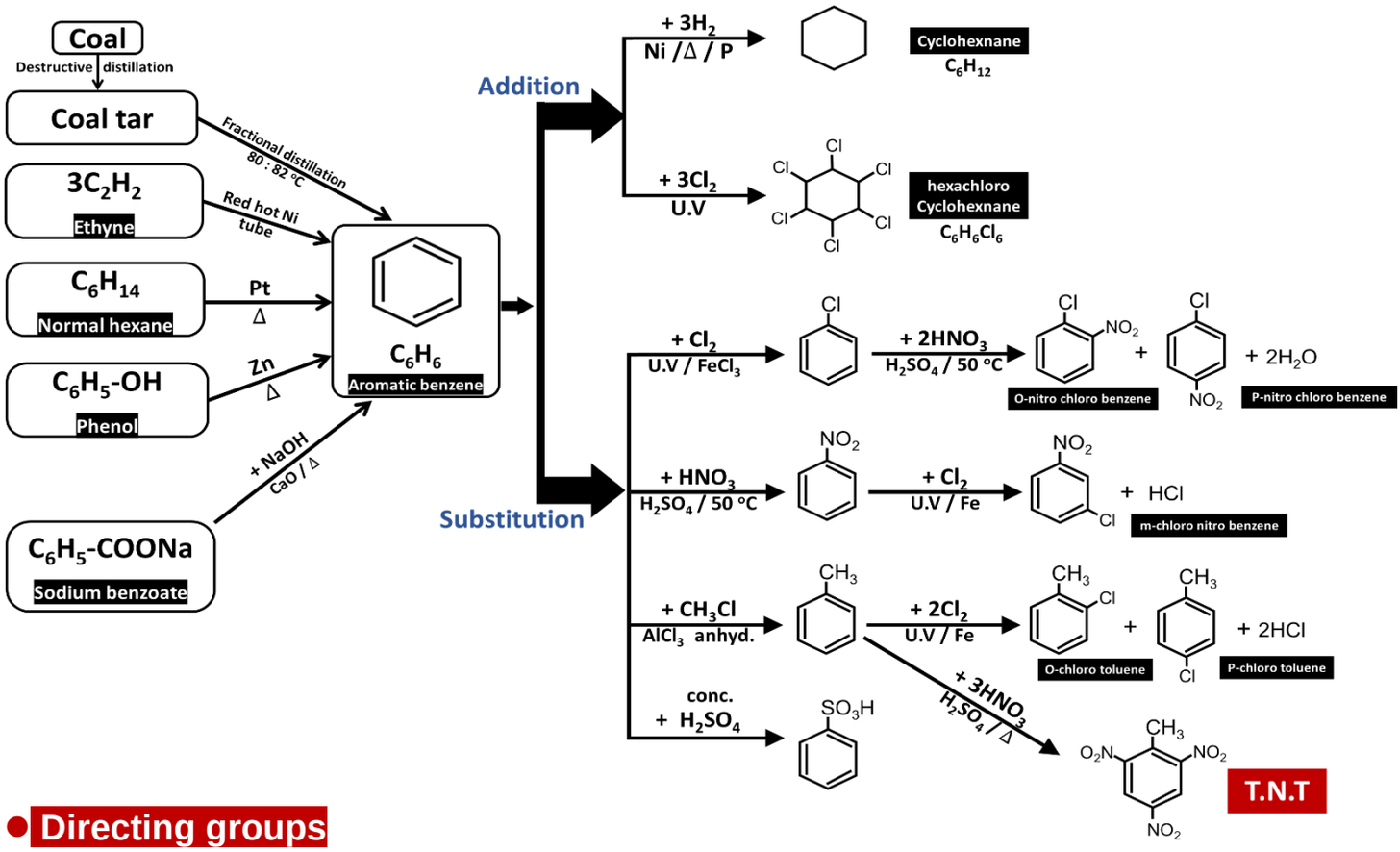


normal propane C_3H_8

As angle between bonds becomes smaller → Overlap of orbitals becomes weaker → Breaking of bonds becomes easier → The compound becomes More active So ..... → Also burned faster

Aromatic Benzene

1 preparation of benzene & chemical properties



Directing groups

Directing groups to ortho & para	Directing groups to meta
Cl- / $-CH_3$ / $-NH_2$ / -OH	$-NO_2$ / $>C=O$ / -COOH / -CHO

Catalytic reforming

Alkane of **6C chain** or more $\xrightarrow{Pt/\Delta}$ ..... + $4H_2$

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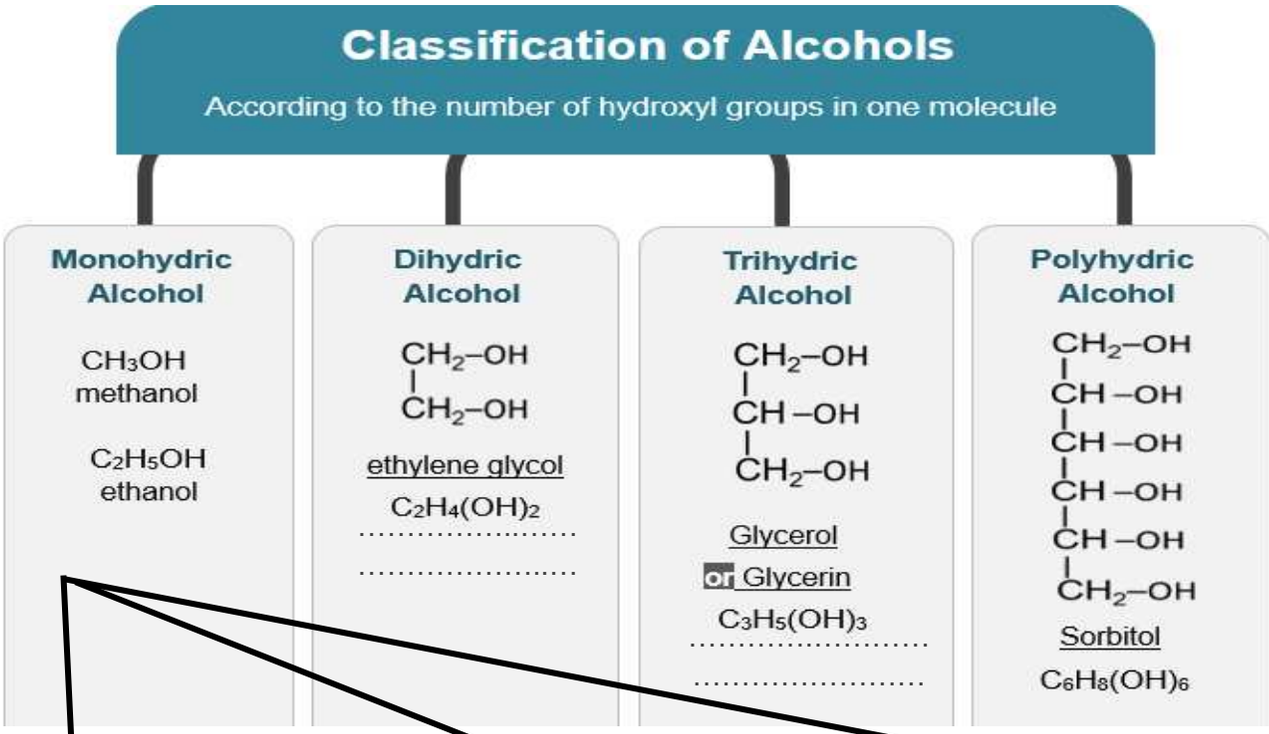
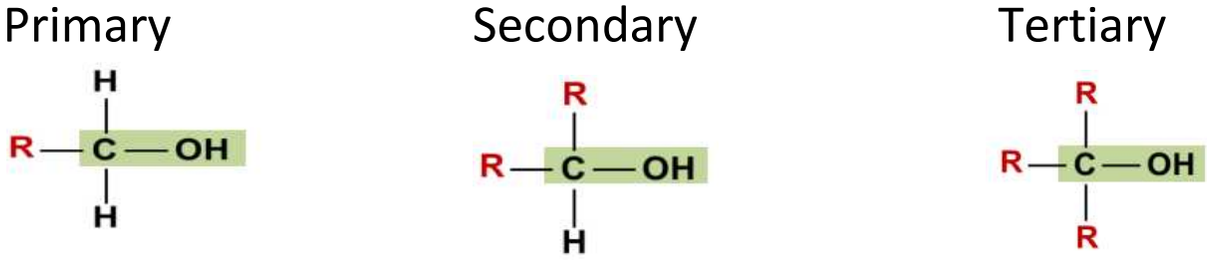
Alcohols

1 Classification & Nomenclature





Common name	Example of alcohol	IUPAC name
..... butyl alcohol	$CH_3–CH_2–CH_2–CH_2–OH$	
..... butyl alcohol	$CH_3–CH_2–\underset{\displaystyle OH}{\underset{\vert}{CH}}–CH_3$	
..... butyl alcohol	$CH_3–\underset{\displaystyle CH_3}{\underset{\vert}{\overset{\displaystyle CH_3}{\overset{\vert}{C}}}}–OH$	
..... butyl alcohol	$CH_3–\underset{\displaystyle CH_3}{\underset{\vert}{CH}}–CH_2–OH$	

Note:

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2 Preparation of alcohols

Alkaline hydrolysis alkyl halide	Catalytic hydration alkene
▪ **Primary alcohol.**	▪ **Primary alcohol.**
$C_2H_5Cl + NaOH_{(aq)} \xrightarrow{\Delta} C_2H_5OH$ Ethyl chloride → Ethanol	$CH_2{=}CH_2 + HOH \xrightarrow[110\ ^oC]{H_2SO_4} C_2H_5OH$ Ethene → Ethanol
▪ **Secondary alcohol.**	▪ **Secondary alcohol.**
$CH_3{-}\underset{Br}{CH}{-}CH_3 + NaOH_{(aq)} \xrightarrow{\Delta} CH_3{-}\underset{OH}{CH}{-}CH_3$ 2-bromo propane (Sec. alkyl halide) → 2-propnanol (isopropyl alc.)	$CH_3{-}CH{=}CH_2 + HOH \xrightarrow[110\ ^oC]{H_2SO_4} CH_3{-}\underset{OH}{CH}{-}CH_3$ propene
▪ **Tertiary alcohol.**	▪ **Tertiary alcohol.**
$CH_3{-}\overset{CH_3}{\underset{CH_3}{C}}{-}Br + NaOH_{(aq)} \xrightarrow{\Delta} CH_3{-}\overset{CH_3}{\underset{CH_3}{C}}{-}OH$ 2-bromo-2-methyl-propane (Ter. Alkyl halide) → 2-methyl-2-propanol (Tertiary butyl alc.)	$CH_3{-}\overset{CH_3}{C}{=}CH_2 + HOH \xrightarrow[110\ ^oC]{H_2SO_4} CH_3{-}\overset{CH_3}{\underset{OH}{C}}{-}CH_3$ 2-methyl-1-propene

➡ **Alcoholic Fermentation for Sucrose (molasses) (sugar cane) :**

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{hydrolysis}} C_6H_{12}O_6 + C_6H_{12}O_6$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Zymase enzyme}]{\text{Yeast}} 2C_2H_5OH + 2CO_2$$
Ethanol

3 Chemical properties

● Reaction specific to –H of –OH

A) Acidity of alcohols :

$$C_2H_5OH \xrightarrow{+\ Na} C_2H_5ONa + H_2\uparrow \quad \textbf{(sodium ethoxide)}$$
$$C_2H_5OH \xrightarrow{+\ NaOH} \textbf{No reaction}$$

Q. How can you differentiate between alcohol & alkane / alcohol & ether ?

B) Esterification :

$$\underset{\text{Acetic acid}}{CH_3CO\overset{16}{O}H\ (L)} + \underset{\text{ethyl alcohol}}{H\overset{18}{O}C_2H_5\ (L)} \xrightarrow[\text{or dry HCl}]{\text{conc. } H_2SO_4} \underset{\substack{\text{ethyl acetate (ester)}\\ \text{has good smell}\\ \text{like fruits \& flowers}}}{CH_3COO\overset{18}{C}_2H_5\ (aq)} + \underset{\text{water}}{H_2\overset{16}{O}\ (L)}$$

● Reaction specific to –OH

$$\underset{\text{ethyl alcohol}}{C_2H_5{-}OH\ (L)} + HCl\ (L) \xrightarrow[\text{cat.}]{ZnCl_2} \underset{\text{ethyl chloride}}{C_2H_5Cl\ (aq)} + H_2O\ (L)$$

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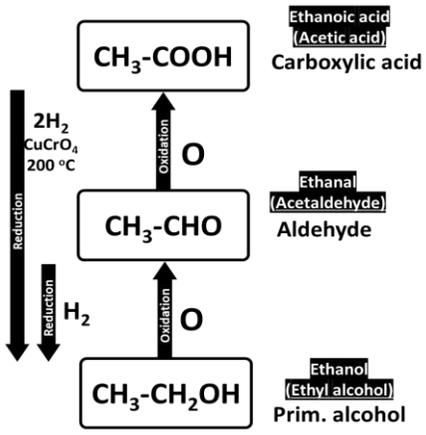
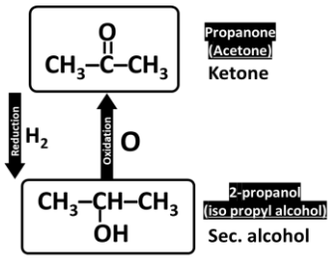
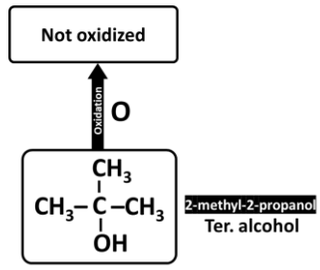
$KMnO_4/H_2SO_4$ Violet → colorless

$K_2Cr_2O_7/H_2SO_4$ Orange → green

Reaction specific to carbinol –C–OH (oxidation of alcohols)







3 يقبلوا الـ OX
- Prim. alc.
- Sec. alc.
- Aldehyde

3 يرفضوا الـ OX
- Tert. alc.
- Acid
- Ketone

1 يقبل الـ OX و الـ Red
- Aldehyde

Reaction specific to whole molecule (dehydration of alcohols by conc. H_2SO_4 at diff. temp.)

The products of reaction of **conc. H_2SO_4** with **alcohol** depend on temperature :

[1] At 180 °C , removing **One** water molecule from **One** alcohol molecule.

$C_2H_5OH_{(L)} \xrightarrow[180\ ^oC]{\text{conc. } H_2SO_4} C_2H_{4\ (g)} + H_2O_{(v)}$

Ethanol → Ethene (alkene)

[2] At 140 °C , removing **One** water molecule from **Two** alcohol molecules.

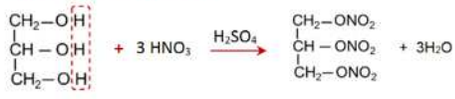
$C_2H_5OH + C_2H_5OH_{(L)} \xrightarrow[140\ ^oC]{\text{conc. } H_2SO_4} C_2H_5-O-C_2H_{5\ (g)} + H_2O_{(v)}$

Ethanol → diethyl ether (common ether)

[3] $C_2H_5-OH + H-OSO_3H \xrightarrow[\text{conc.}]{80\ ^oC} C_2H_5-OSO_3H + H_2O$

ethanol → ethyl hydrogen sulphate

➨ **Nitration of Glycerol** (Glycerin) : ---> **Trinitro glycerin**



Veryyyyyyyyyyyyyy important

7 General formulas of aliphatic compounds

- C_nH_{2n+2} — Alkane
- C_nH_{2n} — ▪ Alkene ▪ Cycloalkane
- C_nH_{2n-2} — ▪ Alkyne ▪ Alkene of 2 (=)
- $C_nH_{2n+2}O$ — Alcohol (R-OH) / Ether (R-O-R)
- $C_nH_{2n}O$ — Aldehyde (R–CHO) / Ketone (R–C(=O)–R)
- $C_nH_{2n}O_2$ — Acid (R-COOH) / Ester (R-COO-R)
- $C_nH_{2n+2}O_2$ — Di-hydric alcohol

but for Aromatic compounds

.....

.....

.....

.....

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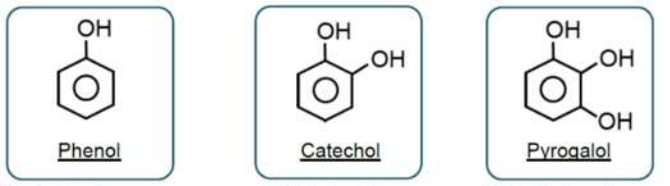
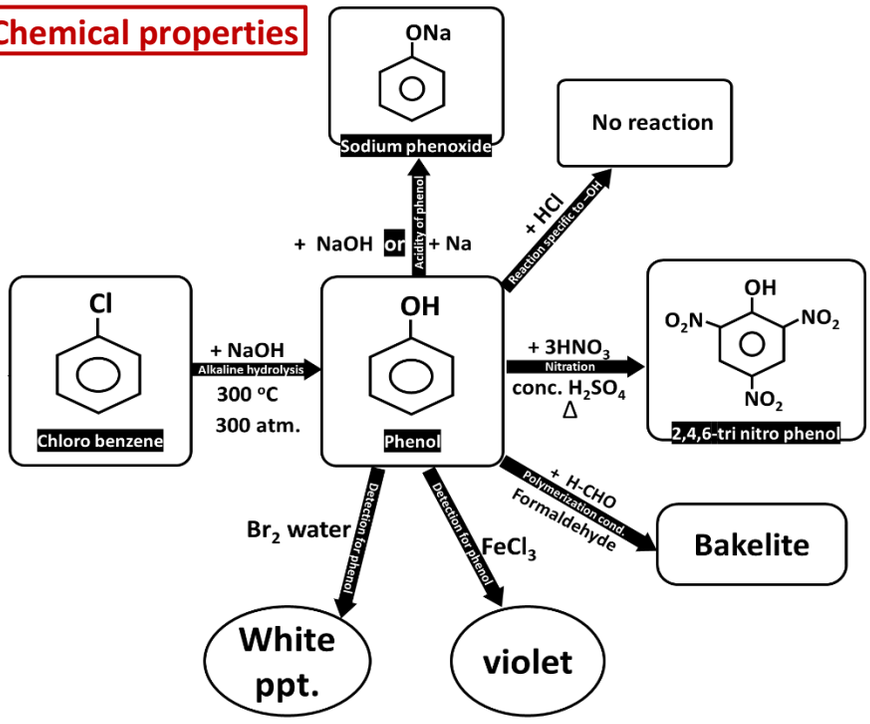
Phenols



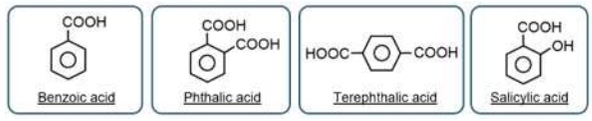
IUPAC name: hydroxy benzene | 1,2-di hydroxy benzene | 1,2,3- trihydroxy benzene

Preparation of Chemical properties



Carboxylic acids (Aliphatic & Aromatic)

Common name		IUPAC name
Formic acid	H–COOH	methanoic acid
Acetic acid	CH_3–COOH	ethanoic acid
Propionic acid	C_2H_5–COOH	propanoic acid
Butyric acid	C_3H_7–COOH	butanoic acid
Palmitic acid	$C_{15}H_{31}$–COOH	hexadecanoic acid



1 Preparation acetic acid

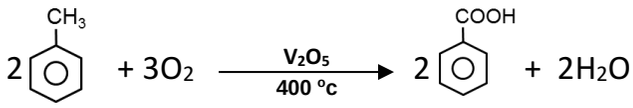
A) Biological method

dilute ethanol (C_2H_5OH) $\xrightarrow[\text{in presence of vinegar bacteria}]{\text{Oxid. by atmospheric } O_2}$ Acetic acid (CH_3COOH)

B) From Acetylene by catalytic hydration followed by oxidation

$$\underset{\text{Acetylene}}{C_2H_{2(g)}} + H_2O_{(L)} \xrightarrow[HgSO_4 \text{ / } 60\ ^oC]{H_2SO_4\ (40\ \%)} \underset{\text{Acetaldehyde}}{CH_3CHO_{(L)}} \xrightarrow[KMnO_4 \text{ / } H_2SO_4]{+\ O} \underset{\text{Acetic acid}}{CH_3COOH_{(L)}}$$

2 Preparation benzoic acid by oxidation of Toluene



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2 Chemical properties

● Reaction specific to –H of –COOH (Acidity & salt formation)

CH_3COOH (Acetic acid)

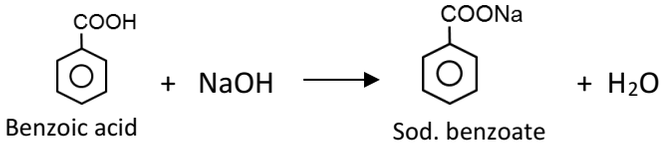
+ Mg / Na (metal) → sodium acetate CH_3COONa + H_2

+ Na_2O (metal oxide) → CH_3COONa + H_2O

+ NaOH (metal hydroxide) → CH_3COONa + H_2O

+ Na_2CO_3 (metal carbonate) → CH_3COONa + H_2O + $CO_2\uparrow$ [Acidity Test]
effervescence & turbid lime water

+ $NaHCO_3$ (metal bicarbonate) → CH_3COONa + H_2O + $CO_2\uparrow$ [Acidity Test]

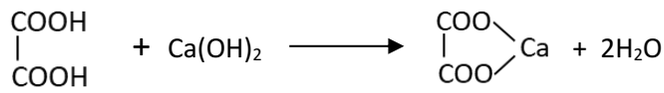


Benzoic acid — Sod. benzoate

➨ **Another reactions of acids to form salt :**

$HCOOH$ + $Ca(OH)_2$ → $(HCOO)_2Ca$

Methanoic acid (Formic acid) — Calcium methanoate (calcium formate)

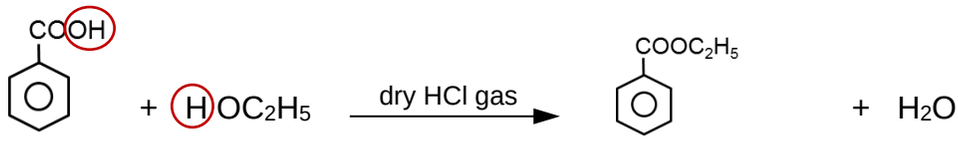


Oxalic acid — calcium oxalate $(COO)_2Ca$

● Reaction specific to –OH (Esterification)

$CH_3CO\,OH$ + $H\,OC_2H_5$ $\xrightarrow[\text{conc.}]{H_2SO_4}$ $CH_3COOC_2H_5$ + H_2O

Acetic acid — Ethyl alcohol — Ethyl acetate (ester)



Benzoic acid — Ethyl alcohol — Ethyl benzoate (ester)

● Reaction specific to –COOH (Reduction of acid)

CH_3COOH + $2H_2$ $\xrightarrow[200\ ^oC]{CuCrO_4}$ CH_3CH_2OH + H_2O

Acetic acid — ethyl alcohol C_2H_5OH

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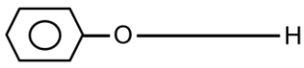
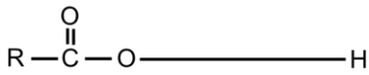
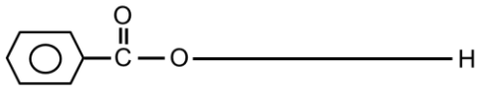
Acidity of ...

Alcohol

Phenol 

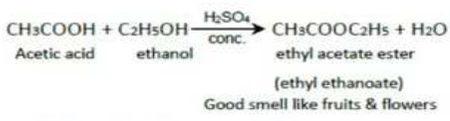
Aliphatic acid 

Aromatic acid 

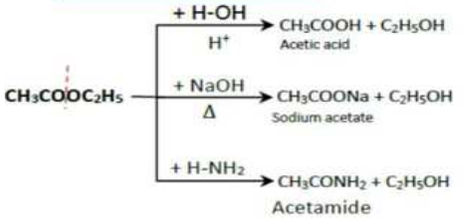
	Metal	Metal hydroxide	Metal oxide	Metal(CO_3^{2-})	Metal(HCO_3^-)
	Na	NaOH	Na_2O	Na_2CO_3	$NaHCO_3$
Alcohol	→				
Phenol	→				
Aliphatic acid	→				
Aromatic acid	→				

Esters

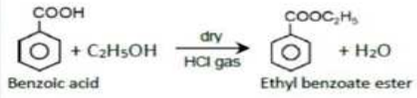
Aliphatic



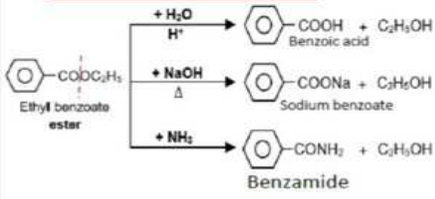
Chemical properties :



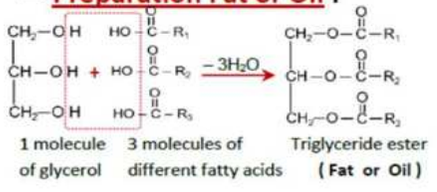
Aromatic



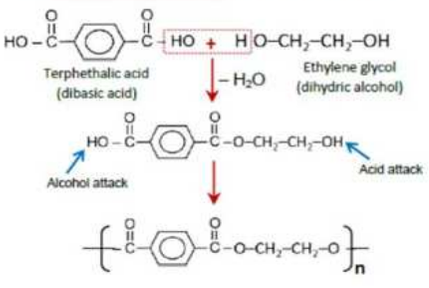
Chemical properties :



Preparation Fat or Oil :

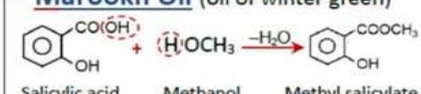


Dacron Fibers (Poly ester) :

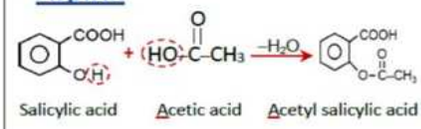


Medical Drugs :

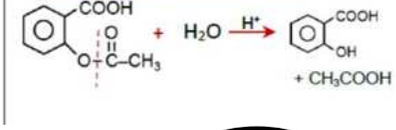
- **Marookh Oil** (oil of winter green)



- **Aspirin**



- **Hydrolysis of Aspirin :**



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